A Methodology and Experimental Study of the DFP / AFCS Systems for Compensating Gravity Distortions on the 70-meter Antenna, Part II

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This paper describes the methodology and experimental study of a deformable flat plate (DFP) and an array feed compensation system (AFCS) on the DSS-14 70-meter antenna at Ka-Band (32-GHz). The main purpose of these technologies is to compensate for the gain loss of the 70-meter antenna at Ka-Band due to gravity induced structural mechanical deformations to its main reflector surface. At Ka-Band these losses were measured to be 3.6 and 6.5-dB at DSS-14 at the low and high elevation angles. The 7 element AFCS is a real-time compensation system that provides the antenna with closed loop pointing, and compensates for distortions due to gravity, and has the potential to compensate for distortions due to thermal gradients, wind, and subreflector misalignments. It was shown that the 16 actuator DFP when combined with a monopulse tracking system, can also provide gravity compensation and closed loop tracking. A novel method for the open loop calibration of a DFP is described and presented. In this presentation we also describe the performance of the combined DFP / AFCS system operating jointly.

The experiment took place between November 14, 1998 and March 1, 1999 when a radio science cone, which is one of the three cones at the cassegrain focus, was removed from DSS-14 antenna for a transmitter upgrade. An older holography cone was retrofitted with the required hardware, RF equipment and instrumentation needed for this study and was lifted and installed in place of the radio science cone. RF optics was designed to image the antenna cassegrain focus above the cone into the holography cone using an ellipsoid, and also provided for an additional position for the AFCS in the usual antenna's cassegrain focus above the cone looking straight at the subreflector. The DFP was mounted approximately half way between the ellipsoid and the feed. The design of this experimental cone provided the following measurement capabilities which formed the methodology for this experiment:

1. Holographic measurements at Ku-Band (12-GHz) utilizing CW beacon signals from geostationary satellites.
2. Total Power Radiometry (TPR) at Ka-Band utilizing wide bandwidth detection of radio sources.
3. Array Feed Compensation System (AFCS) utilizing DS-1 spacecraft CW signal at Ka-Band and wide bandwidth detection of radio sources at Ka-Band.
4. Deformable Flat Plate (DFP) utilizing both CW signals at Ku / Ka-band and wide bandwidth detection of radio sources at Ka-Band.
5. Monopulse tracking utilizing DS-1 spacecraft CW signals at Ka-Band.
6. Joint operation of the DFP / AFCS system

This paper reports:

1. The baseline efficiency performance of DSS-14 70-m antenna at Ka-Band versus predicted performance based on design control tables.
2. A novel methodology for open loop calibration of a DFP.
3. Antenna efficiency performance utilizing the AFCS from both the cassegrain antenna focus as well F2 focus from inside the holography cone.
4. Antenna efficiency with DFP compensation.
5. Performance of a Monopulse tracking with DFP compensation.
6. Joint DFP / AFCS compensation performance.